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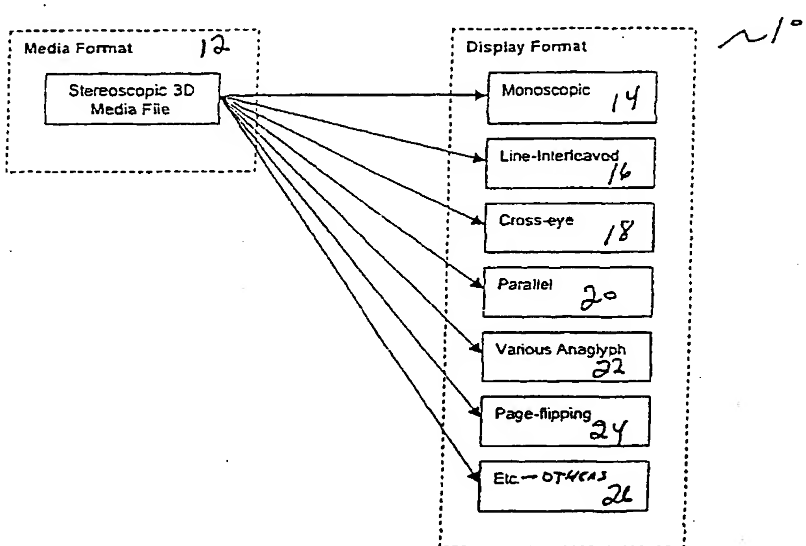
[Continued on next page]

(54) Title: ELECTRONIC STEREOSCOPIC MEDIA DELIVERY SYSTEM



(57) Abstract: The preferred embodiment addresses the problem of delivering stereoscopic media in electronic form (images, videos, animations, object models, etc.). First, it provides a single format with independent right and left channels to represent the stereoscopic media. Second, it provides a means of displaying stereoscopic media inside a movable windowed area while eliminating pseudostereo conditions during movement. Third, it provides automatic and manual optimization adjustments (parallax shift adjustment, brightness control, color adjustment, and cross-talk reduction) to the stereoscopic media based on viewing hardware, monitor size, and media content for optimal viewing quality. Fourth, it provides seamless support for monoscopic (2D) viewing modes allowing delivery of said stereoscopic media in a normal 2D viewing mode.

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ELECTRONIC STEREOSCOPIC MEDIA DELIVERY SYSTEM

TECHNICAL FIELD

The invention is directed to providing a means of delivering stereoscopic media on and off the Internet. In particular the invention provides a means of encoding stereoscopic media, transmitting and storing stereoscopic media, displaying stereoscopic media, and providing helpful tools for viewing the media.

BACKGROUND OF THE INVENTION

Stereoscopic images have been in use for hundreds of years. Recently stereoscopic images, and other forms of stereoscopic media like animations and video, have been converted to electronic form for display on personal computers, the Internet, and on other electronic media like CD-ROMs. Stereoscopic media has been successfully used in numerous applications ranging from medical imaging, to entertainment, to training, to electronic commerce.

Stereoscopic media and viewing systems can take on numerous formats. For example, there are several ways to encode a still stereoscopic 3D image including red/blue anaglyphic format, side-by-side, interleaved or line-alternate formats, etc. There are also numerous viewing systems available to viewing stereoscopic media: red/blue glasses, active shutter glasses, high-speed page-flipping graphics cards with shutter glasses, line-blanking viewing systems, cross-eye lens systems, etc. Many of these media and viewing formats are not compatible with each other. The fact that the stereoscopic media for these various systems is not compatible makes it difficult for a content developer, such as a CD-ROM developer, or Website developer, to support all of the stereoscopic viewing devices on the market.

Several patents contain background information for this disclosure. They include: US Patent 6,028,649 dated 02/22/2000 and entitled "Image Display Systems having Direct and Projection

Polarized Spatially Multiplexed Images of 3-D Objects for Use in Stereoscopically Viewing The Same With High Image Quality and Resolution.

In order to facilitate the growth of stereoscopic 3D media in electronic form, an easy to use, multi-format delivery system is needed. This invention presents new stereoscopic media delivery system that includes means for encoding stereoscopic media, transmitting and storing stereoscopic media, displaying stereoscopic media, and providing helpful tools for viewing the media.

SUMMARY OF THE INVENTION

The preferred embodiment addresses the problem of delivering stereoscopic media in electronic form (images, videos, animations, object models, etc.). Firstly, it provides a single format with independent right and left channels (with an option for mixed or combined right and left channels) to represent the stereoscopic media. Secondly, it provides a means of displaying stereoscopic media inside a movable windowed area while eliminating pseudostereo conditions during movement. Thirdly, it provides automatic and manual optimization adjustments such as parallax shift adjustment, brightness control, color adjustment, and cross-talk reduction to the stereoscopic media based on viewing hardware, monitor size, and media content for optimal viewing quality. Fourthly, it provides seamless support for monoscopic (2D) viewing modes allowing delivery of said stereoscopic media in a normal 2D viewing mode.

These and other features of the present invention will be apparent from the following description of the drawings, detailed description, and appended claims and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates the various display formats embodied in the invention;

Figure 2 illustrates the contents of a window displayed in stereo;

DETAILED DESCRIPTION OF THE INVENTION

The embodiments of the invention include display methods, encoding methods and tools. With regard to display methods this includes a single media file format that is converted to various display formats on the user side; stereoscopic media in a window such as a browser or application; stereoscopic preservation in a window during scrolling and window movement; support of auto-detection 3D stereo hardware systems; script buttons (VRR scripts) to change global stereo formats; stereo media file formats that contain sub media such as VRR and blocks; parallax shift adjustments based on physical size of display window; automatic brightness adjustments; color calibration/adjustments for physical 3D viewing mechanisms, including variations in display devices; crosstalk reduction techniques on user side; smart stereo scaling; integration of stereo media types into one viewer with script interaction; monoscopic and stereoscopic viewing that allows greater distribution since both types can be viewed within one system; save and conversion of one format into another from the Internet using a local drive from the original source; automatic free view image size adjustment to minimize viewing fatigue; pseudostereo correction based on image processing of a few lines or the entire image; scaling stereo media, so that the left and right sources are preserved; and improvements to Anaglyph display methods. Since the format of the original left and right is known, as designated by the tag within the Stereoscopic 3D Media file, the scaling can be done while preserving stereo. Additionally, looking at the storage method used, it is necessary to take the appropriate actions to scale the media while preserving the stereo and to perform scaling done to increase or decrease the display size of the stereoscopic media.

In existing systems, stereo media can only be viewed at the original size. The embodiment of Figure 1 provides a mechanism to increase or decrease the size at which the media is displayed while preserving the stereo. As shown in Figure 1 with analysis 10, the left and right media are extracted

current vertical location of the window, and then places the first line of the stereo image on an even scan line. Whenever a user scrolls within that window, or moves the window itself, the application checks the odd/even status, and adjusts accordingly. In the case of vertically scrolling within a window or if the window itself is moved, the first line of the stereo image is placed on an even scan line. When the image is scrolled vertically, movement is done in even increments so as to maintain stereo or the right and left images are swapped for each pixel move to maintain stereo. For the case of horizontal scrolling, the same methods as vertical scrolling apply.

To display interleaved stereo images in a window or on a full-screen, the left and right fields or views must be preserved and presented consistently. For example the first horizontal line of a stereo image that is presented within a window may represent the right field or view and the second horizontal line the left field or view. In this example, the first horizontal line of the display device is even, or represented by a zero, the right field/view is to be presented on even scan lines, and the left field/view is to be presented on odd scan lines to maintain stereo. If the left field/view were presented on the even scan lines and the right field/view on the odd lines, then the result would be pseudostereo. The selection of associating the right field/view with even scan lines is arbitrary – the reverse can also be true provided consistency is maintained. The left field/view may be on the odd scan lines, the right field/view on the even.

The exemplary embodiment preserves left field/view and right field/view in a several ways. A first method is to snap the window to an even scan line, which ensures that the window starts on an even horizontal scan line. Another method is to look at the even/oddness of the first horizontal line where the stereo media starts. If the right field/view is on the even scan line, and the left field/view is on the odd, then no action is required, otherwise the left/right fields/views can be swapped – placing the left content on the even lines, and the right content on odd, for every horizontal line in the media,

details of a line-interleaved stereo image. The even line of the stereo image is not aligned with an even scan line of the monitor, which results in the display of a pseudoscopic, or reverse image.

Figure 4 illustrates the contents of a scrolling window displayed in stereo 300. A stereo image is presented on a computer screen in a window 302. This particular window scrolls vertically. The first line of the image is aligned on an even scan line 304 with the monitor, which allows for stereoscopic presentation. Whenever vertical scrolling occurs, even increments are made so that the image is always presented in stereo.

Figure 5 illustrates a General Software Flowchart 400. Upon start 402, the application checks to see where the image starts, on an even or odd scan line 404. If on an even scan line 406, a stereo image is then displayed 408. If the image starts on an odd scan line 410, then the image is shifted to an even scan line or the left and right field/views are swapped and then displayed 412. Vertical scrolling begins 418 and is done by an even increment 420.

To scale stereo media, the left and right source must be preserved. Since the format of the original left and right is known, as designated by the tag within the Stereoscopic 3D Media file, scaling can be done while preserving stereo. An embodiment ooks at the storage method used, then takes the appropriate actions to scale the media while preserving the stereo. Scaling may done to increase or decrease the display size of the stereoscopic media.

Figure 6 illustrates an analysis of the left and right media 500 that are extracted from the Stereoscopic 3D Media file 502, individually scaled504, 506, recombined into the selected display 508, and then the resulting scaled Stereoscopic Media is displayed 510.

To scale stereo media, the left and right source must be preserved. Since the format of the original left and right is known, as designated by the tag within the Stereoscopic 3D Media file, the scaling can be done while preserving stereo. The system will look at the storage method used, and then

This is accomplished by showing either the left or right mono image. The user can select whether to view the left or right monoscopic view. Users without a physical stereo viewing device can see the media in monoscopic form by selecting to use either the right or left monoscopic views.

An embodiment of the invention contains automatic adjustment of Brightness/Contrast/Image properties adjustment based on viewing mechanism. No prior Electronic viewing system adjusts media brightness/contrast based upon the display method. This embodiment adjusts the final display of the stereo media to accommodate LC shutter-glasses, and LC shutter-glasses with line-blanker type products. When stereo media is viewed through an LC shutter-glass viewing system it appears darker due to the shuttering system. Additionally when stereo media is viewed through an LC Shutter-glass coupled with a line blanker, the media appears even darker. This embodiment will adjust the brightness, contrast and other media properties to compensate for the color distortion/darkness incurred by the viewing mechanism. Figure 8 illustrates the automatic adjustment of Brightness/Contrast/Image properties adjustment based on viewing mechanism 700. The Stereoscopic Media file 702 is queried and is displayed using shutter glasses 704. The Brightness adjustment system 706 adjusts the brightness of the media file to accommodate the physical viewing mechanism 708. This same embodiment can compensate for uneven image luminance between the left and right eyes when using anaglyphic colored viewing glasses.

Algorithms are used to reduce crosstalk between the left and right views. Other stereoscopic viewing systems do not incorporate a system to reduce crosstalk. Crosstalk often appears in stereo media and can be referred to as ghosting. Bright in one eye, dark in the other, occupying the same point in the scene can create crosstalk. Areas of high contrast in stereo media are subject to crosstalk. This ghosting occurs because each eye is seeing some of the media intended only for the other eye, and in this case there may be very bright content in one eye, and darker content in the other eye.

There is an embodiment that saves and converts one format into another from the Internet using a local drive from original source. The viewing system takes a Stereoscopic Media File, displays it on the user side according to the user's display preferences, and saves a local copy in whatever display format the user selects. The system can convert the Stereoscopic Media into the display method selected by the user, and save the result on the user's local drive. Alternately, the original form of the Stereoscopic 3D Media file may be saved on the user's local drive. This embodiment makes it possible to support special 3D formats that are not easy to generate in real time.

A color calibration/adjustment for physical 3D viewing mechanisms, compensates for variations in the display devices. An embodiment includes the functionality to adjust stereo media properties, thereby preserving the original color, hues, saturation, etc. when viewed through a physical viewing mechanism. For example, when looking through liquid crystal shutter-glass systems, the LC may introduce additional yellow coloring to the subject matter. Based on the user's view settings that tell the originator what kind of viewing device the user may be using. Another embodiment of the invention corrects for distortions introduced by the viewing mechanism. Another example could be for anaglyph viewing. For this example, the viewing system goes through a color calibration to attempt to more closely match the coloring of the anaglyph lenses with the coloring of the monitor or display device.

A stereo media file format may contain certain sub media such as VRR and blocks. An embodiment supports a stereoscopic media file that contains sub-media. Specifically, a file structure is created to store and preserve various types of stereo media in various formats. Additionally, this file format can also store monoscopic media, as well as audio or other data. This one file format can store multiple or single stereo/non-stereo media elements. Figure 10 illustrates a VRR file 1000 that may contain a script 1002, a Stereo Still Image 1004, a Stereoscopic Animation/movie 1006, Stereoscopic

Another embodiment automatically (or manually if desired) adjusts with overall left and right image shift to compensate for image magnification. When a 3D stereoscopic image is enlarged and displayed on a viewing system that has a larger image size then the target system, there is a potential of creating large separations between objects in the 3D stereoscopic image that can lead to eyestrain for the viewer. The present invention stores important parameters about the 3D stereoscopic image like width, height, target screen size, etc. When the 3D stereoscopic image is to be displayed on a display that is larger or smaller than the target screen size, then the 3D stereoscopic image is adjusted accordingly to minimize eye fatigue for the user.

One embodiment utilizes image processing to detect pseudo-stereo 3D stereoscopic content. It is common for content authors to sometimes reverse the right and left eyes when creating 3D stereoscopic content. When this happens, the display system will present the wrong image to the viewer's eyes. This embodiment attempts to correct this problem by comparing portions of the right and left image content to determine if a pseudo condition exists and then swaps the right and left images to correct for the problem.

Another embodiment encodes the full-color left and right images in separate channels and compresses the left and right channels independently. This technique provides less compression artifacts and reduces crosstalk when compared to anaglyphic storage techniques. In comparison, analgyph storage techniques, which are widely used on the Internet, combine the right and left images in separate color channels of a single image and then compressed the resulting image. This technique results in the introduction of crosstalk because most compression techniques, like JPEG that is commonly used, reduce the color space of an image drastically, which in turn compromises the quality of the Anaglyphic storage technique.

One embodiment stores a series of 3D stereoscopic images of an object into one file. Figure 16 illustrates one way to store a series of N images into a single resource file. The first image 1600 is at the top of the file and the rest of the images follow sequentially until the last file 1602. The collection of these images forms an object movie data file 1604. Figure 17 shows the relationship between the images and the object in question 1700. As the figure illustrates, the point of view of the camera is swung around the object to generate all of the intermediate images. When these images are displayed in a sequential fashion, it appears that the object is rotating on the screen in 3D depth. When the images are displayed in reverse order, the object appears to turn in the opposite direction. If the playback of the images is linked to the right/left movement of a mouse point on the screen, it will appear that the user is actually rotating the object on the screen. This example illustrates a one dimensional object movie. It is possible to store additional sets of rotational images sets to simulate other views of the object (example: doors open or closed on a car model).

Another embodiment allows a larger 3D stereoscopic image or panorama to be scrolled within a smaller viewing window as shown in Figure 18. The viewing window 1802 is a fixed size and does not move with respect to the viewing screen. The 3D stereoscopic image 1800 is larger than the viewing window and therefore must be scrolled horizontally and vertically within the viewing window in order for the viewer to see the entire image. This is always the case with panoramic images that contain a very wide or tall view of a scene. When the image is panned within the viewing window, the invention ensures that the left and right views are presented to the correct eyes. For example, in the row interleaved viewing method, if the larger 3D stereoscopic image is moved vertically by a single pixel, the image will flip into pseudostereo mode. The present invention will either shift the image an additional line to make it viewable in non-pseudostereo or it will flip the left and right images to

morphing techniques to synthesize a new right and left image that are closer together. The same technique can be used to simulate a wider stereoscopic camera separation to increase the depth effect. The amount of adjustment can be selected by the user to suit their viewing condition and capabilities. Figure 19 illustrates an original right 1902 and left 1904 camera views of an object 1900. The new synthesized right 1906 and left 1908 views will be easier to view for some users.

Another embodiment of the invention provides an automatic alignment and/or re-alignment of the left and right images. Many 3D stereoscopic images are created incorrectly and may have vertical, horizontal, or rotational misalignment that will cause eyestrain for the viewer. Using image correlation techniques, horizontal and vertical misalignment of the right and left views is corrected. Further correlation is applied to correct for rotational alignment issues.

Another embodiment provides a tool that compares the left and right images to determine if stereoscopic information is lost during compression. Compression is used to reduce the size of a stereoscopic image so that it can be easily transmitted over a low bandwidth connection. If too much compression is applied, the image will loose its stereoscopic impact. This embodiment provides a measure of the quality of the stereoscopic image that can be used to readjust the compression system.

Another embodiment allows both local content, residing on the users workstation, and remote content, residing on a server or web site to be viewed using the display methods. This embodiment is needed to allow for remote streaming playback as well as to allow for local playback of files that are delivered via cd-rom or other storage means or for content that is downloaded from a remote location to a local storage location before being displayed.

View 2 can be combined to form a left right pair (respectively). The next 3D stereoscopic view is formed by combining view 2 with view 3 (left and right respectively). Each image in the original object movie is used twice. If the original 2D object movie contains enough images (60 images produces good results) then the converted 3D object movie will be usable. If there are not enough images, less than 40, then better results are achieved if the previously mentioned embodiment of generating intermediate views using image interpolation can be applied to the object movie conversion. Using image interpolation allows intermediate stereoscopic views to be generated, which have much less camera separation and are easier to view.

The present invention can also be embodied in the form of computer program code, for example, whether stored in a storage medium, loaded into and/or executed by a computer, or transmitted over some transmission medium, such as over electrical wiring or cabling, through fiber optics, via electromagnetic radiation or via the Internet, wherein, when the computer program code is loaded into and executed by a computer, the computer becomes an apparatus for practicing the invention. When implemented on a general-purpose microprocessor, the computer program code segments configure the microprocessor to create specific logic circuits.

The modifications to the various aspects of the present invention described above are merely exemplary. It is understood that other modifications to the illustrative embodiments will readily occur to persons with ordinary skill in the art. All such modifications and variations are deemed to be within the scope and spirit of the present invention as defined by the accompanying Claims.

7. The method of claim 1 further-comprising stereoscopic preservation in a window during scrolling and window movement.

8. The method of claim 1 comprising supporting of auto-detection 3D stereo hardware systems.

9. The method of claim 1 comprising script buttons (VRR scripts) for changing global stereo formats.

10. The method of claim 9 further comprising stereoscopic media file formats that contain sub media such as VRR and blocks.

11. The method of claim 1comprising parallax shift adjustments based on a physical size of display window.

12. The method of claim 1 further comprising automatic brightness adjustments.

13. The method of claim 1 further comprising color calibration/adjustments for physical 3D viewing mechanisms, including variations in display devices.

14. The method of claim 1 further comprising crosstalk reduction techniques on a user side.

15. The method of claim 1 further comprising smart stereo scaling.

16. The method of claim 1 further comprising integration of stereo media types into one viewer with script interaction.

17. The method of claim 1 further comprising monoscopic and stereoscopic viewing that allows greater distribution since both types can be viewed within one system.

18. The method of claim 1 comprising saving and converting one format into another from the Internet using a local drive from an original source.

19. The method of claim 1 further comprising automatic free view image size adjustment to minimize viewing fatigue.

30. The method of claim 29 including using stereoscopic panning that preserve the stereo image alignment. 31. The method of claim 30 uses a co-existence of Java software and a plug-in solution to minimize downloading.

32. The method of claim 31 using image interpolation to generate in between stereo views to minimize or maximize the stereo separation

33. The method of claim 32 using image interpolation for converting a 2D object movie to a 3D stereoscopic object display and provide a background download capability.

Figure 1:

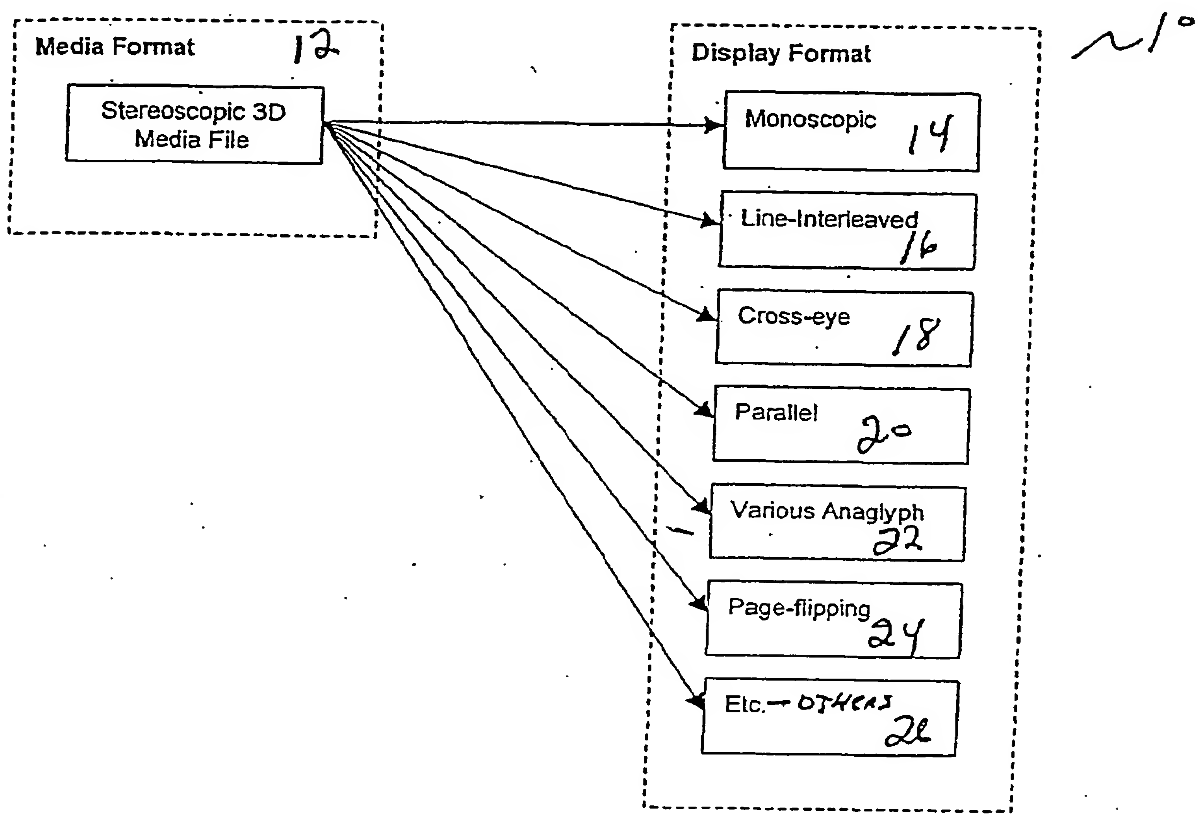
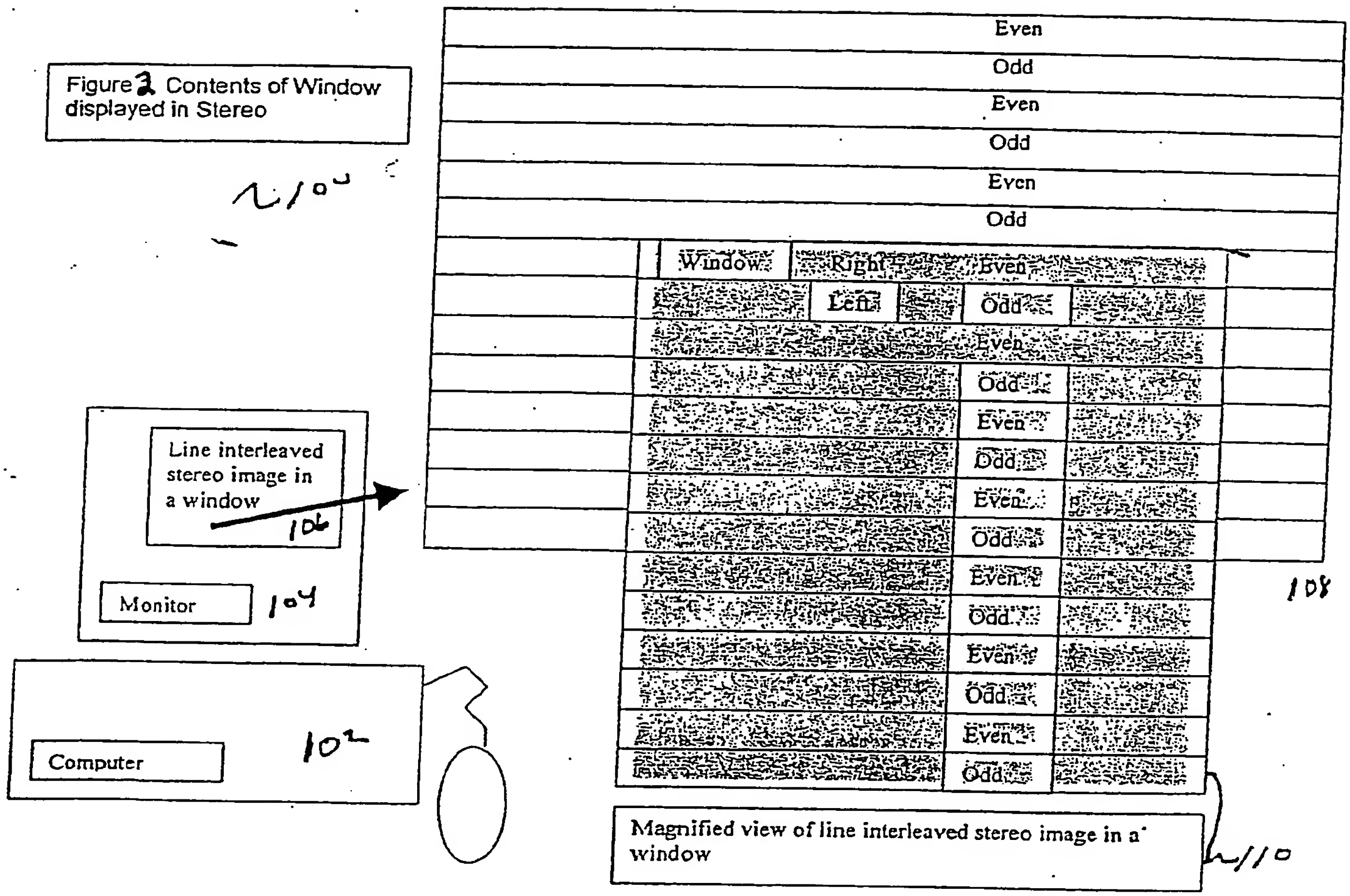

Media Format
12
Stereoscopic 3D Media File
Display Format
10
Monoscopic
14
Line-Interleaved
16
Cross-eye
18
Parallel
20
Various Anaglyph
22
Page-flipping
24
Etc.→ OTHERS
26

Figure 2 Contents of Window displayed in Stereo



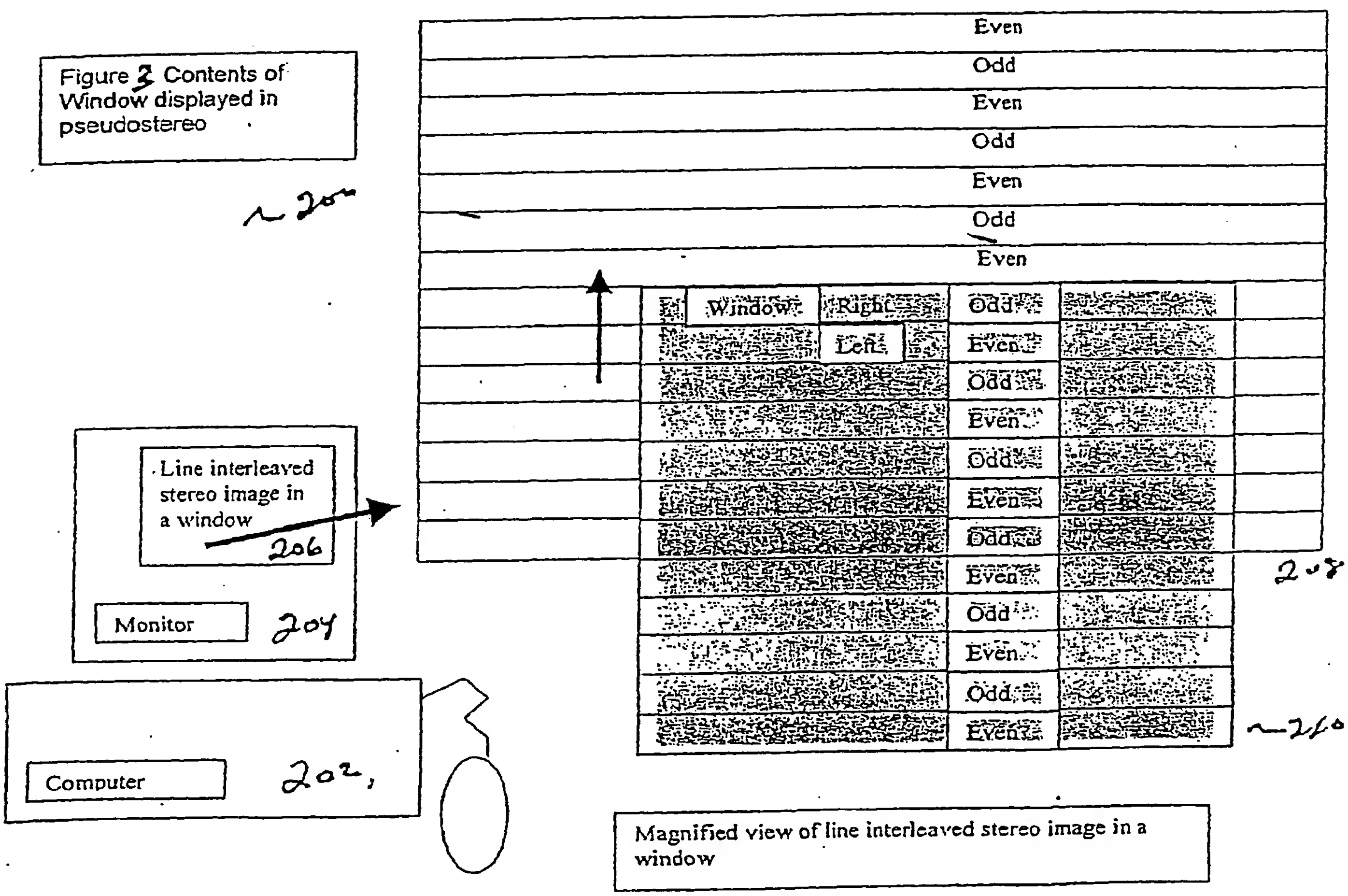
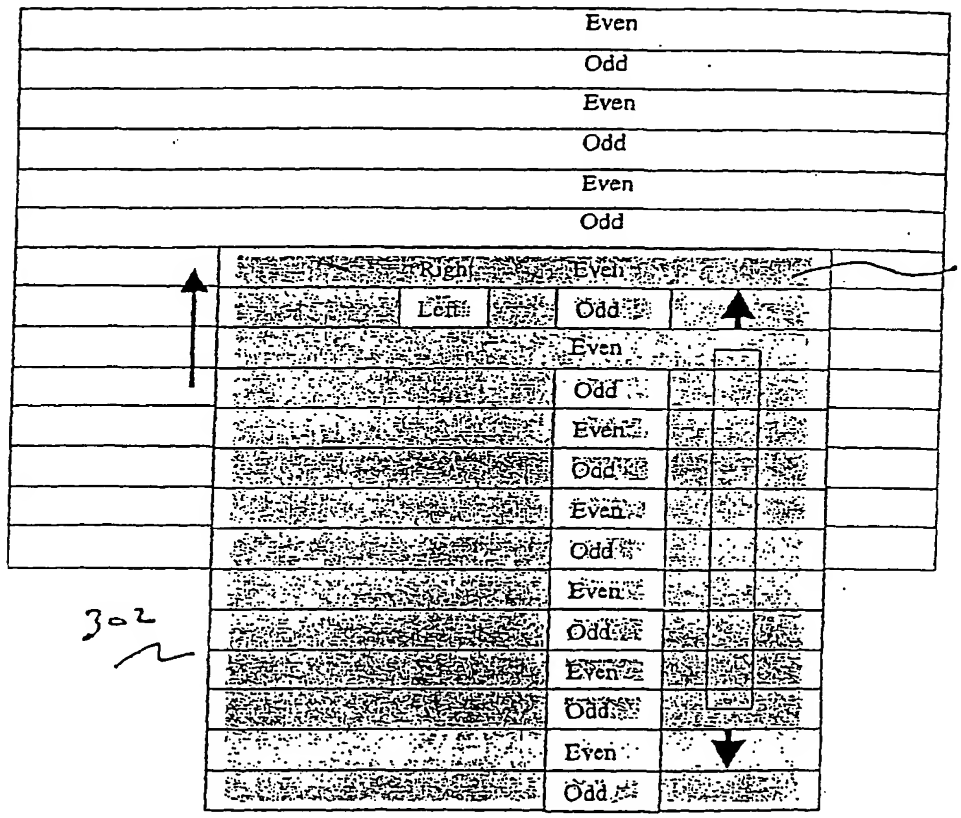


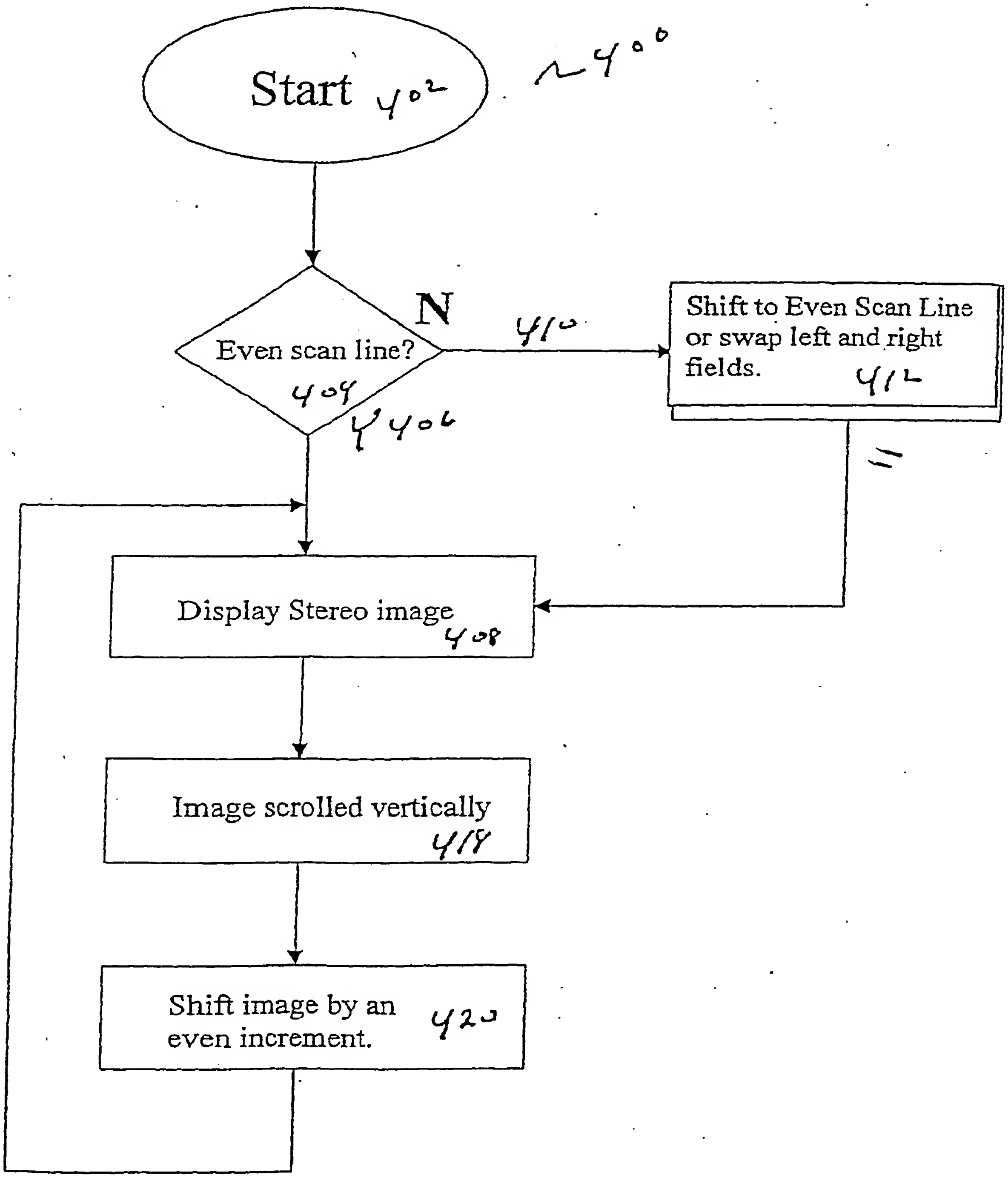
Figure 3 Contents of Window displayed in pseudostereo

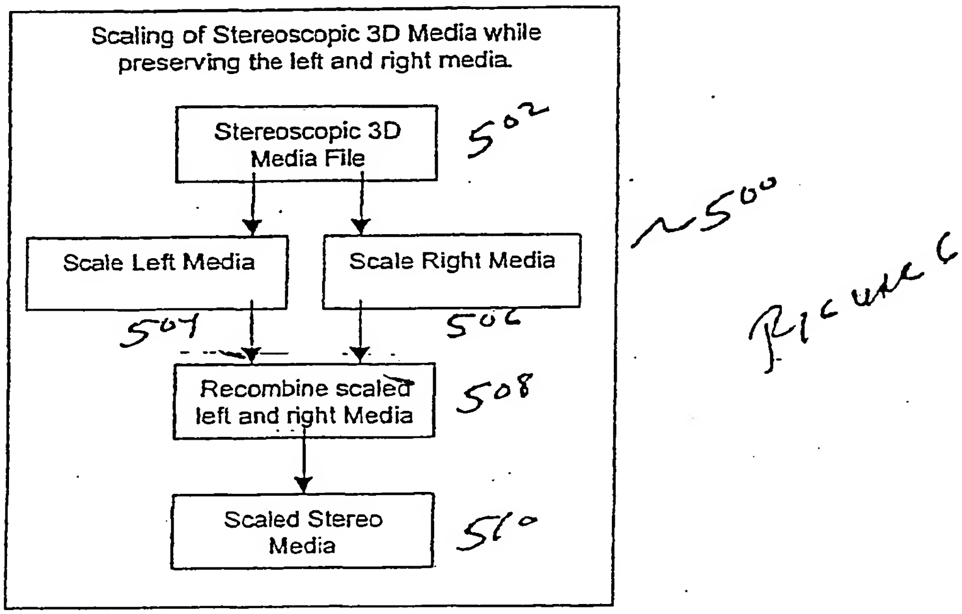
Figure 4. Contents of scrolling Window displayed in Stereo



Magnified view of line interleaved stereo image in a window

Figure 5 General Software flowchart




Scaling of Stereoscopic 3D Media while preserving the left and right media.
Stereoscopic 3D Media File
502
Scale Left Media
Scale Right Media
504
506
Recombine scaled left and right Media
508
Scaled Stereo Media
510
500
FIGURE 6

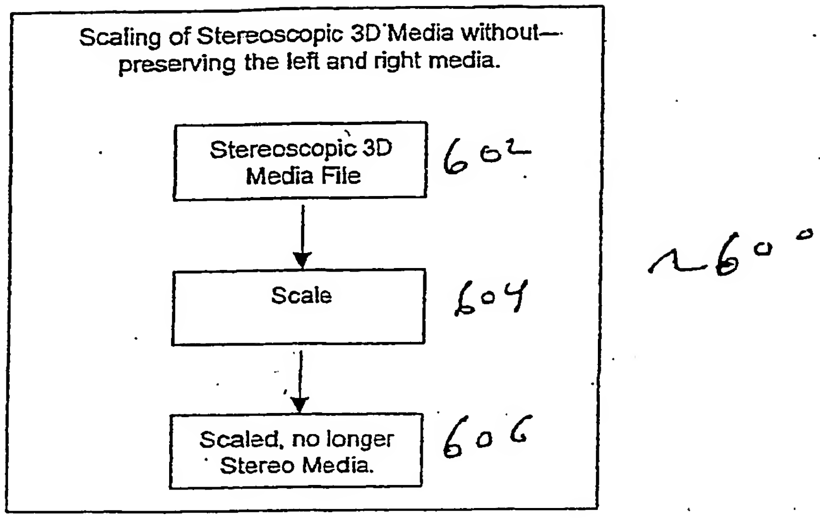

Scaling of Stereoscopic 3D Media without preserving the left and right media.
Stereoscopic 3D Media File
602
Scale
604
Scaled, no longer Stereo Media.
606
600

FIGURE 7

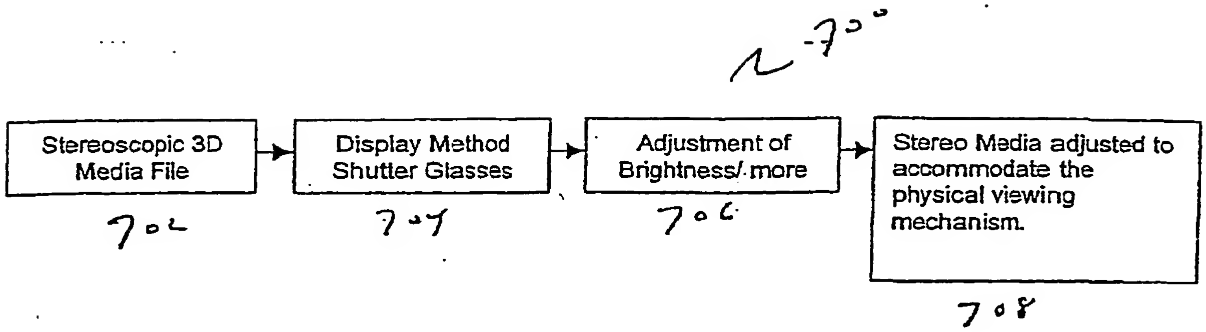

700
Stereoscopic 3D Media File
702
Display Method Shutter Glasses
704
Adjustment of Brightness/more
706
Stereo Media adjusted to accommodate the physical viewing mechanism.
708

FIGURE 8

Figure 9

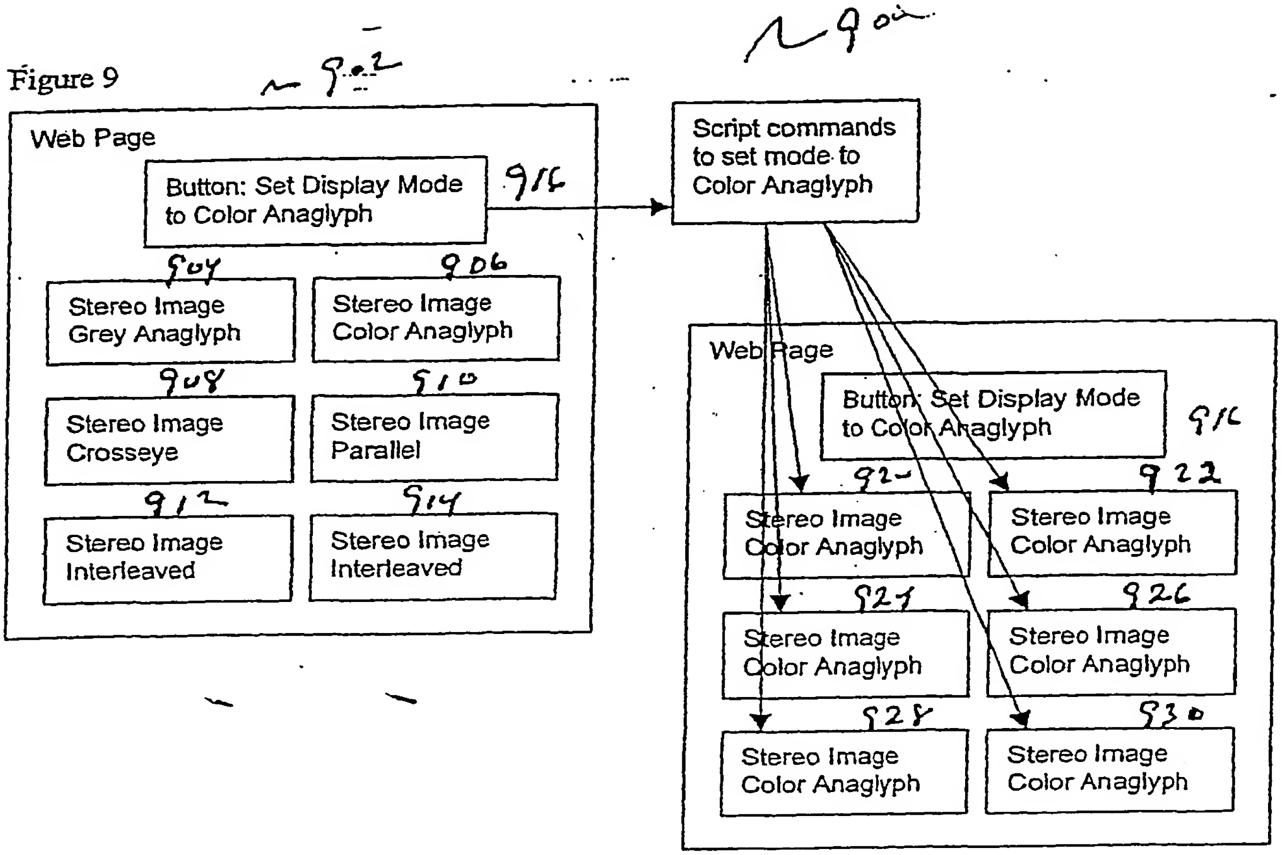
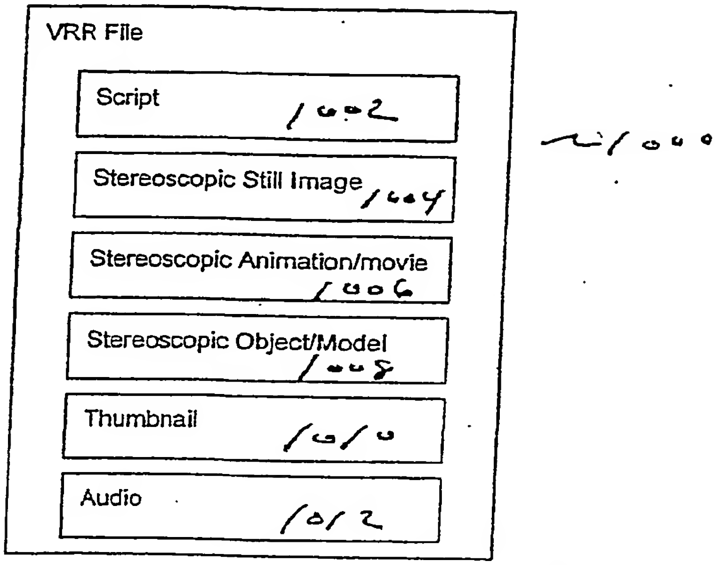

902
900
Web Page
Button: Set Display Mode to Color Anaglyph
916
904
906
Stereo Image Grey Anaglyph
Stereo Image Color Anaglyph
908
910
Stereo Image Crosseye
Stereo Image Parallel
912
914
Stereo Image Interleaved
Stereo Image Interleaved
Script commands to set mode to Color Anaglyph
Web Page
Button: Set Display Mode to Color Anaglyph
916
920
922
Stereo Image Color Anaglyph
Stereo Image Color Anaglyph
924
926
Stereo Image Color Anaglyph
Stereo Image Color Anaglyph
928
930
Stereo Image Color Anaglyph
Stereo Image Color Anaglyph

FIGURE 10


VRR File
Script 1002
Stereoscopic Still Image 1004
Stereoscopic Animation/movie 1006
Stereoscopic Object/Model 1008
Thumbnail 1010
Audio 1012
1000

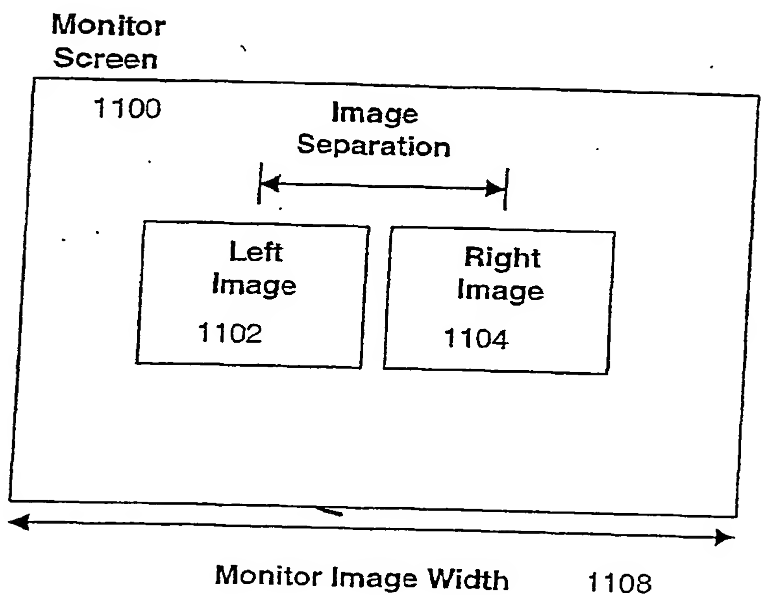

Monitor
Screen
1100
Image
Separation
Left
Image
1102
Right
Image
1104
Monitor Image Width
1108

Figure 11

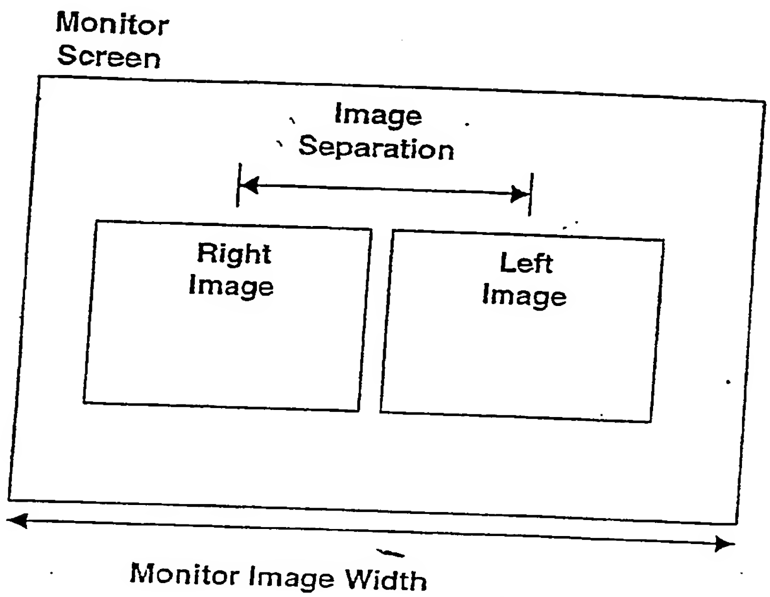


Figure 12

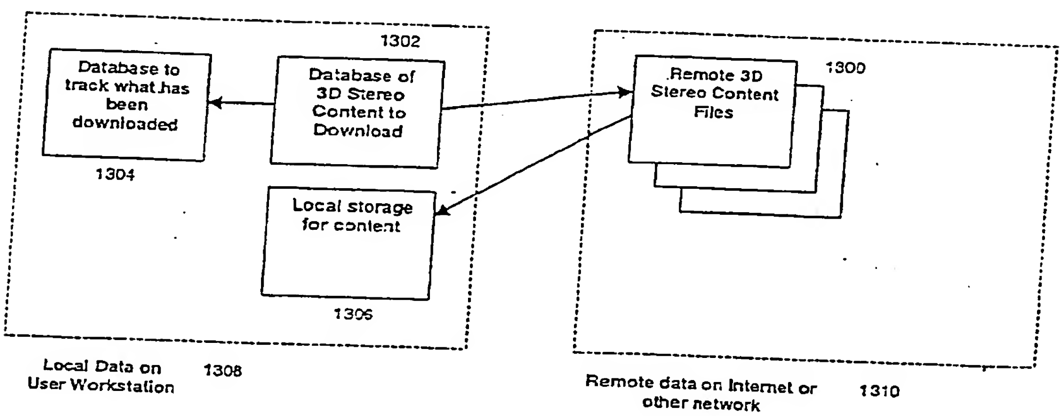


Figure 13

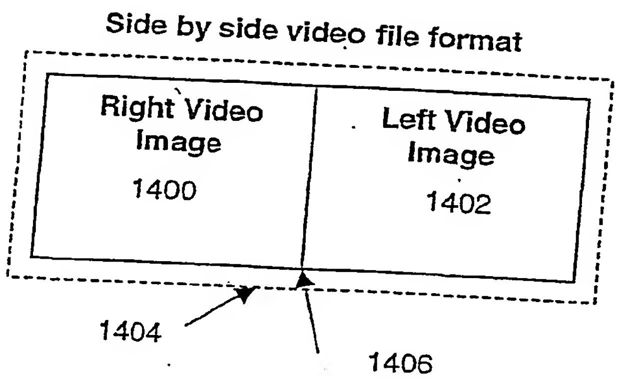

Side by side video file format
Right Video Image
1400
Left Video Image
1402
1404
1406

Figure 14

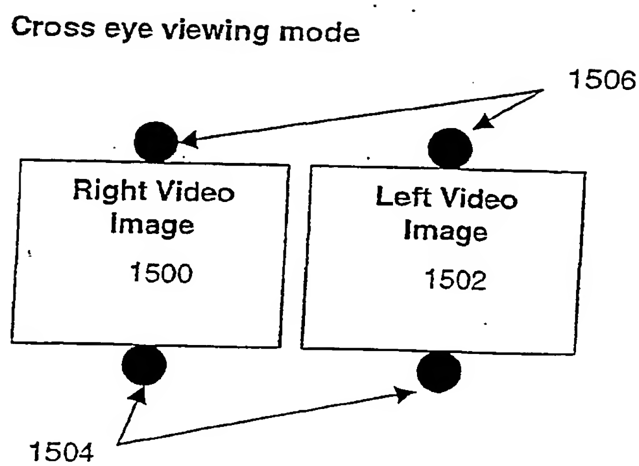

Cross eye viewing mode
1506
Right Video Image
1500
Left Video Image
1502
1504

Figure 15

Object Movie VRR File

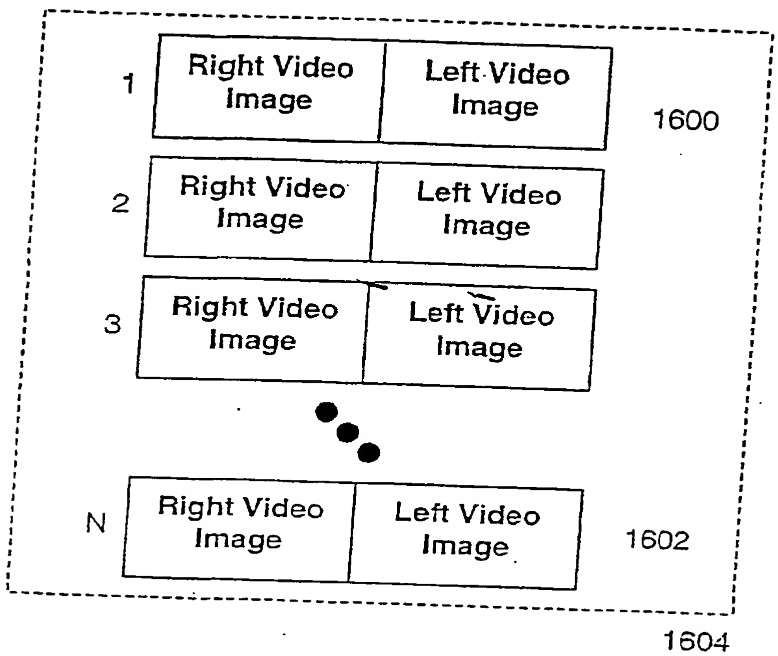


Figure 16

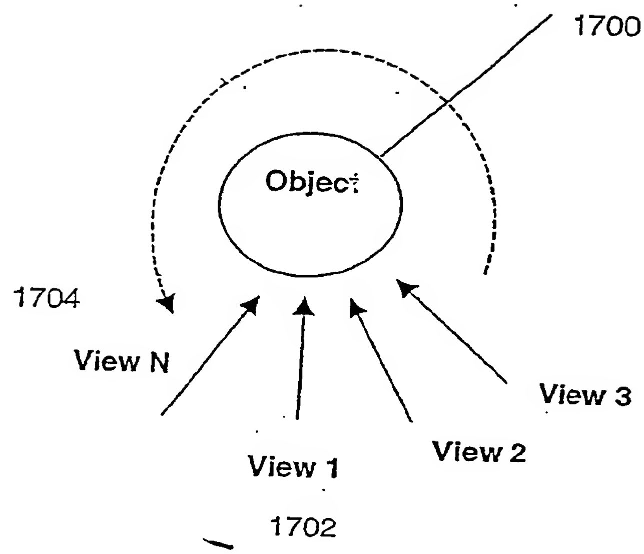


Figure 17

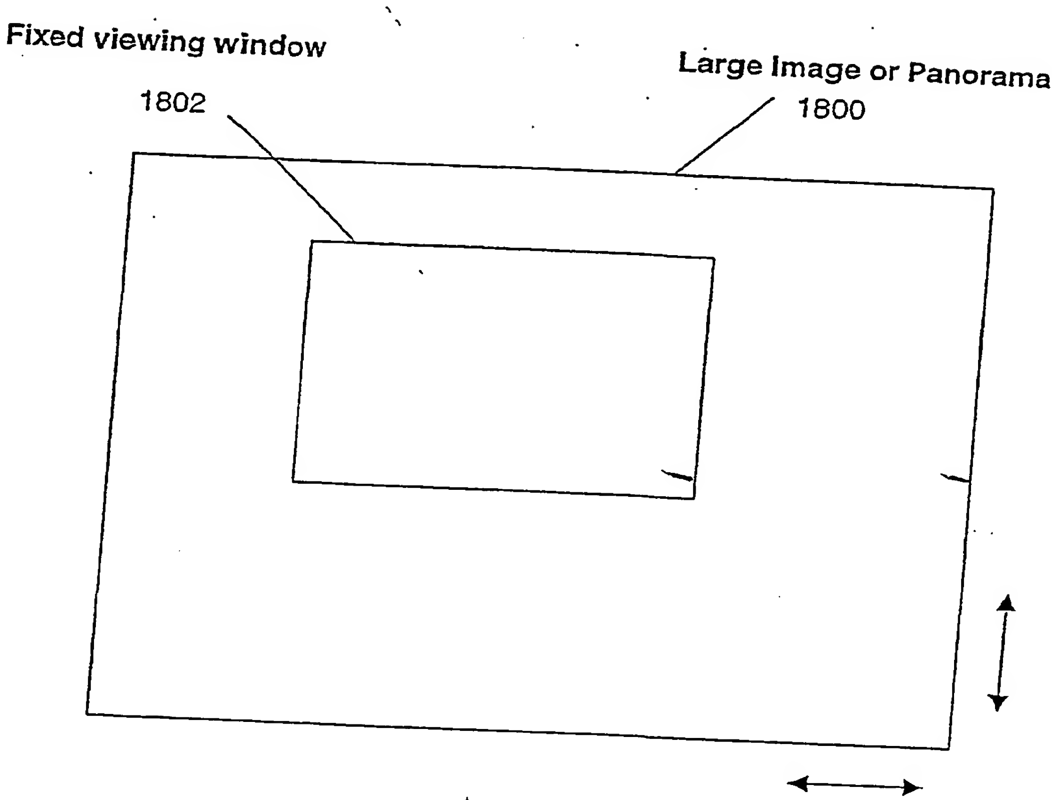


Figure 18

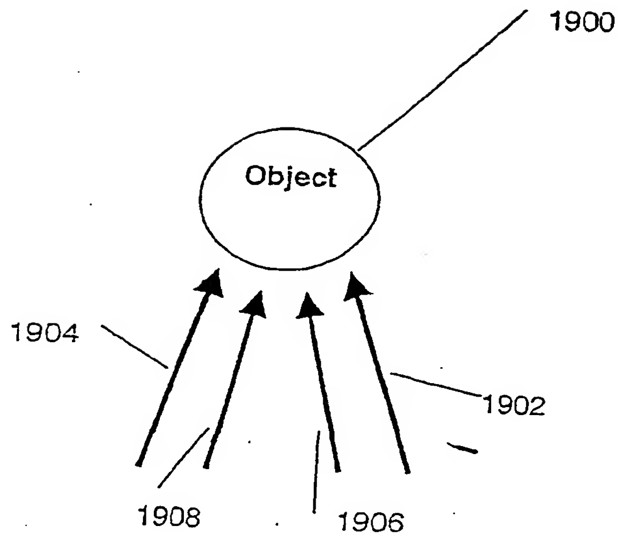


Figure 19

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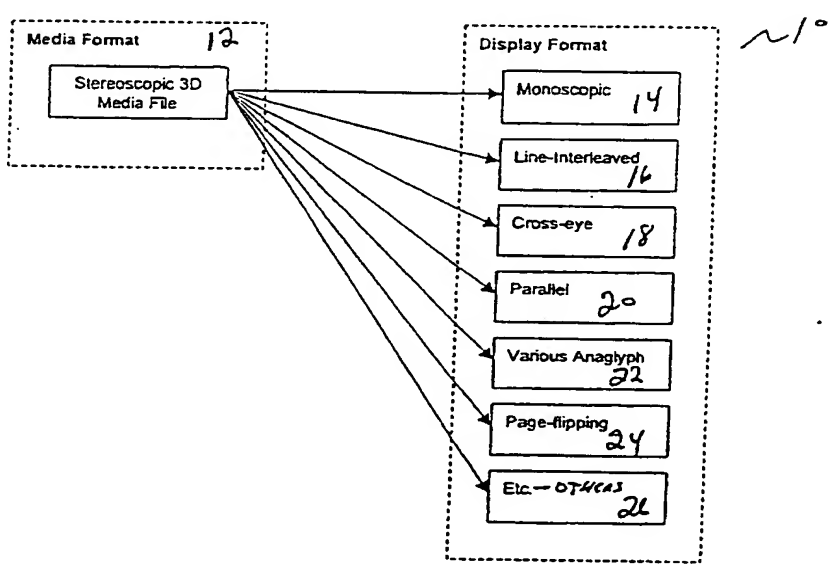
[Continued on next page]

(54) Title: ELECTRONIC STEREOSCOPIC MEDIA DELIVERY SYSTEM



(57) Abstract: The preferred embodiment addresses the problem of delivering stereoscopic media in electronic form (images, videos, animations, object models, etc.). First, it provides a single format with independent right and left channels to represent the stereoscopic media. Second, it provides a means of displaying stereoscopic media inside a movable windowed area while eliminating pseudostereo conditions during movement. Third, it provides automatic and manual optimization adjustments (parallax shift adjustment, brightness control, color adjustment, and cross-talk reduction) to the stereoscopic media based on viewing hardware, monitor size, and media content for optimal viewing quality. Fourth, it provides seamless support for monoscopic (2D) viewing modes allowing delivery of said stereoscopic media in a normal 2D viewing mode.

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